Complications Associated With Autologous Rib Cartilage Use in Rhinoplasty
A Meta-analysis

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IMPORTANCE  Although autologous rib cartilage is a preferred source of graft material in rhinoplasty, rib cartilage for dorsal augmentation has been continuously criticized for its tendency to warp and for high donor-site morbidities. However, no meta-analysis or systemic review on complications associated with autologous rib cartilage use in rhinoplasty has been conducted.

OBJECTIVE  To carry out a systematic review and a meta-analysis of available literature to evaluate complications regarding autologous rib cartilage in rhinoplasty.

DATA SOURCES  The studies reporting complications associated with the autologous rib cartilage use in rhinoplasty were systematically reviewed by searching the MEDLINE, PubMed, and Embase databases for sources published from 1946 through June 2013.

STUDY SELECTION  The selected articles included clinical studies conducted with at least 10 patients and at least 1 postoperative long-term complication or donor-site morbidity in rhinoplasty. Excluded were nonhuman studies; review articles; case reports; abstracts; and reports of nasal reconstruction as indication for surgery, use of homologous rib cartilage, and diced or laminated methods.

DATA EXTRACTION AND SYNTHESIS  Two investigators independently reviewed all studies and extracted the data using a standardized form. A meta-analysis was performed using a random-effects model.

MAIN OUTCOMES AND MEASURES  Number of patients; follow-up duration; and rates of complication, donor-site morbidity, and revision surgery. Also noted were study authors and year of publication.

RESULTS  Ten studies involving a total 491 patients were identified. Mean follow-up across all studies was 33.3 months. In meta-analysis, the combined rates were 3.08% (95% confidence interval [CI], 0%-10.15%) for warping, 0.22% (95% CI, 0%-1.25%) for resorption, 0.56% (95% CI, 0%-2.61%) for infection, 0.39% (95% CI, 0%-1.97%) for displacement, 5.45% (95% CI, 0.68%-13.24%) for hypertrophic chest scarring, 0% (95% CI, 0%-0.32%) for pneumothorax, and 14.07% (95% CI, 6.19%-24.20%) for revision surgery.

CONCLUSIONS AND RELEVANCE  The overall long-term complications and donor-site morbidity rates associated with autologous rib cartilage use in rhinoplasty were low. Warping and hypertrophic chest scarring showed relatively higher rates, warranting a surgeon's attention. Because a limited number of studies and patients were eligible, and consistent definitions of complications were lacking in this meta-analysis, future studies with a larger series of patients and objective outcome measurements are needed to obtain more reliable results.

LEVEL OF EVIDENCE  4.
Autologous materials, such as septal, conchal, and rib cartilages, are generally accepted as the gold standard of graft material for rhinoplasty. Autologous rib cartilage is a preferred source of graft material owing to its robust strength and ample volume when a substantial amount of dorsal augmentation is needed. However, the use of rib cartilage for dorsal augmentation has been often criticized for its tendency to warp and its high donor-site morbidities, such as pneumothorax and postoperative scarring. Although the reports about the surgical results and complications associated with autologous rib cartilage use in rhinoplasty have been sporadic, the extant studies either enrolled relatively small numbers of patients or used shorter follow-up periods. For evidence-based recommendations delineating ideal uses, a large-scale study with long-term follow-up data are necessary. To overcome these limitations, a systematic review or meta-analysis on these complications can be a substitute, which to our knowledge has not been conducted previously. The objective of this study was to systematically evaluate the current literature on autologous rib cartilage for dorsal onlay graft in rhinoplasty and to assess the long-term complications through a meta-analysis.

Methods

Literature Search
Two of us (J.H.W. and H.-R.J.) independently searched MEDLINE, PubMed, and Embase databases for articles published from 1946 through June 2013 for all available studies reporting complications and donor-site morbidities associated with the autologous rib cartilage use in rhinoplasty. Keywords used in this search were “rhinoplasty or augmentation,” “costal or rib,” and “cartilage,” with limits activated to exclude articles about other than human species and those written in languages other than English. References from all identified studies were systematically searched to identify any supplementary sources.

Inclusion and Exclusion Criteria
The inclusion criteria for the current meta-analysis of clinical rhinoplasty studies were as follows: (1) report of at least 1 complication (warping, resorption, infection, and/or displacement) and rates of donor-site morbidity (hypertrophic scarring and/or pneumothorax) and revision surgery rates; (2) autologous rib cartilage used for dorsal onlay graft; and (3) follow-up of more than 1 year.

The following types of publications were excluded: (1) animal studies, in vitro studies, review articles, case reports, and abstracts; (2) studies with fewer than 10 patients; (3) studies lacking accessibility to original articles (eg, only abstracts) and/or with incomplete data; (4) duplicate publications; (5) reports of nasal reconstruction as indication of surgery; (6) reports of homologous rib cartilage graft; and (7) reports of diced or laminated methods.

Data Extraction and Statistical Analysis
Two investigators reviewed all studies independently and extracted the data using a standardized form. For each article that reported the results from the use of autologous rib cartilage in rhinoplasty, the following information was noted: author; year of publication; number of patients; duration of follow-up; and rates of complications, donor-site morbidities, and revision surgical procedures. The analysis of pooled proportions was performed, while cases of missing or incomplete information were excluded. Weighted proportions and their 95% confidence intervals (CIs) for the percentage of complications, donor-site morbidities, and revision surgery were calculated.

A random-effects model meta-analysis was used, which assumes that the true underlying effect between studies varies. To assess heterogeneity across the studies, the Cochran Q test and F statistic (for the percentage of overall variation) were used. P < .01 for the Cochran Q test was considered to indicate significant heterogeneity among studies. Since the F statistic describes the percentage of total variation across studies due to heterogeneity rather than chance, F < 25%, F = 25% to 50%, and F > 50% represented low, moderate, and high degrees of inconsistency, respectively. Potential publication bias was evaluated using funnel plots. The meta-analyses were performed using the software package R for Windows, version 3.0.1 (R Foundation for Statistical Computing).

Results

Where possible, the results were described according to the PRISMA guidelines (Preferred Reporting Items for Systematic reviews and Meta-Analyses).

Characteristics of the Studies
A flow diagram of the initial identification, reasons for exclusion, and final selection of studies is shown in Figure 1. The search strategy identified 547 unique abstracts, of which 32 appeared to meet initial screening criteria. After reviewing full-length articles, 19 studies were excluded for the following reasons: follow-up duration shorter than 1 year (n = 12); only an abstract present (n = 4); sample size smaller than 10 patients (n = 1); rib cartilage used for sites other than the dorsum (n = 1); and review article (n = 1). Three additional studies were excluded for lack of quantifiable data. One study6 was excluded because it reported mixed results (septal, conchal, and rib cartilages). Three reports7,10,11 used the same data from the same patients; therefore, only data from the first one4 were included, and the other studies10,11 were excluded.

Ten studies2-4,12-18 met all inclusion criteria for the meta-analysis (Table); all were retrospective case series. The included studies were performed between 2002 and 2013, and a total 491 patients were evaluated. The mean follow-up duration was 33.3 months across all studies. Weighted percentages are shown via forest plots in Figure 2.

Complications
The data of warping and resorption rates were available in 9 studies for 458 patients in total. The weighted mean percentage of warping was 3.08% (95% CI, 0%-10.15%) (Figure 2A). Although heterogeneity was seen across studies, overall rate was low. The weighted mean proportion of resorption was 0.22%
Donor-Site Morbidities and Revision Surgery Rates

Only 5 studies comprising 291 patients reported rates of hypertrophic chest scarring. The weighted mean percentage of hypertrophic chest scarring was 5.45% (95% CI, 0.68%-13.24%) (Figure 3A). The rates of pneumothorax were available in 8 studies for 405 patients in total. The pooled proportion of pneumothorax was 0% (95% CI, 0%-0.32%) (Figure 3B). Seven studies reported revision surgery rates in a total 304 patients. The combined rate of revision surgery was 14.07% (95% CI, 6.19%-24.20%) (Figure 3C).

Publication Bias

There was no publication bias found in any analysis except warping and pneumothorax. Although publication bias for analysis of warping was seen across studies ($P = .04$), the funnel plot did not show a noticeable asymmetry (Figure 4A). The analysis of pneumothorax rates showed certain publication bias ($P < .001$) with an asymmetric funnel plot (Figure 4B).

Table. Summary of Clinical Studies Included in Meta-analysis*

<table>
<thead>
<tr>
<th>Study</th>
<th>Follow-up, Mean (Range), mo</th>
<th>Outcomes of Interest, No. (%)</th>
<th>Warping</th>
<th>Resorption</th>
<th>Infection</th>
<th>Displacement</th>
<th>Hypertrophic Chest Scar</th>
<th>Pneumothorax</th>
<th>Revision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cakmak and Ergin,13 2002b (n = 20)</td>
<td>17.0 (8-32)</td>
<td>1 (5.00)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (5.00)</td>
<td>0</td>
<td>NR</td>
</tr>
<tr>
<td>Shubailat,14 2003 (n = 47)</td>
<td>96.0 (12-120)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NR</td>
<td>NR</td>
<td>0</td>
<td>8 (17.02)</td>
<td></td>
</tr>
<tr>
<td>Riechelmann and Rettinger,15 2004 (n = 43)</td>
<td>24 (NR)</td>
<td>0</td>
<td>NR</td>
<td>2 (4.65)</td>
<td>1 (2.33)</td>
<td>0</td>
<td>NR</td>
<td>9 (20.93)</td>
<td></td>
</tr>
<tr>
<td>Cervelli et al,4 2006c (n = 33)</td>
<td>NR (12-96)</td>
<td>NR (1.03)</td>
<td>0</td>
<td>1 (3.03)</td>
<td>0</td>
<td>NR</td>
<td>0</td>
<td>3 (9.09)</td>
<td></td>
</tr>
<tr>
<td>Yilmaz et al,1 2007d (n = 38)</td>
<td>27.4 (15.8-54.5)</td>
<td>4 (10.53)</td>
<td>0</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>0</td>
<td>9 (23.68)</td>
<td></td>
</tr>
<tr>
<td>Al-Qattan,12 2007 (n = 21)</td>
<td>48.0 (24-72)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5 (23.81)</td>
<td>0</td>
<td>1 (4.76)</td>
<td></td>
</tr>
<tr>
<td>Christophel and Hilger,16 2011a (n = 39)</td>
<td>24.0 (12-NR)</td>
<td>0</td>
<td>1 (2.56)</td>
<td>NR</td>
<td>1 (2.56)</td>
<td>NR</td>
<td>0</td>
<td>12 (30.77)</td>
<td></td>
</tr>
<tr>
<td>Park and Jin,2 2012f (n = 83)</td>
<td>29.5 (6-73)</td>
<td>5 (6.02)</td>
<td>2 (2.41)</td>
<td>5 (6.02)</td>
<td>0</td>
<td>2 (2.41)</td>
<td>0</td>
<td>2 (2.41)</td>
<td></td>
</tr>
<tr>
<td>Tastan and Sozen,17 2013g (n = 43)</td>
<td>19.2 (12-37)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miranda et al,18 2013h (n = 124)</td>
<td>36.0 (12-NR)</td>
<td>32 (25.81)</td>
<td>0</td>
<td>0</td>
<td>NR</td>
<td>12 (9.68)</td>
<td>0</td>
<td>NR</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: NR, not reported.

* All included studies were retrospective case series.
* Complications were evaluated by patient examination and serial facial photographs.
* Resorption was defined as irregularity of the dorsum.
* Warping was defined as patient-determined poor nasal symmetry; resorption was defined as collapse and change in the nasal shape as determined by anthropometric measurements of standardized preoperative and postoperative lateral photographs.
* Complications were assessed by standard photographs and telephone survey.
* Resorption was defined as dorsal height reduction; warping was defined as dorsal deviations as evaluated by other surgeons using preoperative and 1-year postoperative photographs.
* Complications were evaluated by physical examination and with serial facial photographs.
* Warping was defined as deviated or raised nasal dorsal lines.
Warping is often considered the most common complication of rib cartilage use in rhinoplasty, but our analysis showed a relatively low rate of warping (3.08%). A marked heterogeneity (I² = 87.6%; P < .001) and publication bias in analyzing warping rates are generally considered to be caused by limited reports available in review and the extremely variable warping rates (1 study reported an extremely high rate, and others reported a rate of 0%–12%). We assume that the actual warping rate would be higher than we found it to be. The reported rate
in published articles probably reflects only moderate to severe warping and excludes minimal to minor warping.

Infection and displacement rates of the rib cartilage were very low in our study. A low infection rate seems natural, given the autogenous character of the study material. In our experience, an autologous rib cartilage graft is generally stabilized and does not show any significant resorption after 1 year postoperatively. However, resorption is a lifelong process.

Heterogeneity (P = .003; I² = 75.4%) was seen across 5 studies that were included in the analysis of hypertrophic chest scarring rates.2,5,13,15,18 The small number of reviewed studies might explain the heterogeneity; the Cochran Q statistic has poor power to detect true heterogeneity in a meta-analysis that includes a small number of studies.3,6 In addition, ethnic differences among patients can cause heterogeneity, although we could not assess the effect of the race because most studies did not report the patients’ races. Of the 5 studies that evaluated hypertrophic chest scarring,2,5,13,15,18 Al-Qattan13 reported the highest rate and found that high rate to be associated with patient ethnicity (African and Asian patients). Our experience is consistent with this observation. Our patients are exclusively Asian, and we frequently see hypertrophic chest scarring that needs treatment with silicone gel or sheets or triamcinolone injection.

All analyzed studies reported a pneumothorax rate of 0%, which can be considered as a publication bias. Although a pneumothorax is a rare complication when harvesting a rib cartilage, it can happen even with an experienced surgeon. Careful dissection preserving the posterior perichondrium is mandatory to prevent this complication.

All studies included in this review reported relatively long-term (>1 year) outcomes. Most complications appear during this period, and judging the complication rate after a year seems rational, although there are debates about this time frame. In our experience, an autologous rib cartilage graft is generally stabilized and does not show any significant resorption after 1 year postoperatively. However, resorption is a lifelong pro-
cess and “true” long-term results might be evaluated more than 10 years after surgery.

This study has some limitations. First, a small number of published articles reported rib cartilage use in rhinoplasty, and this makes the sensitivity analysis or subgroup analysis impossible. Second, many articles that reported rib cartilage use in rhinoplasty did not meet the inclusion criteria that we set to warrant quality analysis. Third, even the selected articles have some weak points. They use a relatively small number of patients, had heterogeneous patient groups (mixed primary and revision cases), and did not offer detailed descriptions of the surgical techniques used. In addition, most selected articles reported only whether resorption occurred or not and did not detail consistent definitions and objective measures for complications. A few studies had definitions for resorption, such as collapse and change in the shape of the nose or dorsal height reduction, but these definitions also relied on subjective findings without objective measurements.

Nonetheless, to our knowledge, the present study is the first systemic review and meta-analysis of the autologous rib cartilage use in rhinoplasty, especially focusing on the use of cartilage as the dorsal onlay graft. Even with some heterogeneity and bias, these results still give us useful information on the complications of rib cartilage use in rhinoplasty.

Our findings indicate that the most frequent complications are warping and chest hypertrophic scarring, and this result suggests that these complications are somewhat unavoidable, even for skillful surgeons. Because using autologous rib cartilage in rhinoplasty has a steep learning curve and requires refined surgical skills, the rate of these complications will be definitely higher for unskilled surgeons. Accordingly, autologous rib cartilage needs to be used judiciously by an experienced surgeon after obtaining consent from the patients.

Conclusions

The overall long-term complications associated with autologous rib cartilage use in rhinoplasty were low. Because warping and hypertrophic chest scarring had relatively high rates, surgeons should pay more attention to reduce these complications. A limited number of studies and patients eligible for analysis and lack of consistent definitions for complications are main drawbacks of this study. Future analysis should include studies with larger pool of patients, clearer definitions of complications, and longer-term follow-up to obtain more reliable results.
Statistical analysis: Oh.
Administrative, technical, or material support: Wee, Park.
Study supervision: Jin.
Conflict of Interest Disclosures: None reported.

REFERENCES